

Some Perspectives on Scientific Ballooning and Earth Sciences



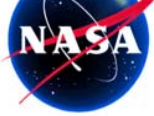
***Marty Mlynczak
Climate Science Branch
NASA Langley Research Center***

***NASA Scientific Balloon Community Workshop
August 7, 2007
Washington, DC***

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- Some historical aspects of Earth Science and the Balloon program
 - Historical aspects of satellite instrument development and scientific balloons
 - Scientific Ballooning and Earth Science Missions in Development (launching by ~2010)
 - Ballooning to NRC Earth Science Decadal Survey Missions (2010-2020)
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- **Three functions historically:**
 - Correlative Measurements (e.g., UARS)
 - Science
 - e.g., FIRS-2 and OH, HO₂, etc.
 - Technology/Instrument Demonstrations
 - IRIS FTS, Palestine, TX, 1960's
 - Nimbus III, IV
 - LACATE limb sounder, White Sands, early 1970's
 - Nimbus VI, VII
 - Microwave Limb Sounder, (late 1970's?)
 - UARS, EOS AURA
 - FIRST FTS, 2005, 2007
 - Decadal Survey Mission

Some Historical Background Ballooning and Earth Sciences



- **Ozone Photochemistry -- 1980 to 1995**
 - About 1/3 to 1/2 of balloon program was involved with UARS measurements and validation via NASA UARP
 - National and international payloads
 - Example: FIRS-2 instrument (Harvard SAO)
 - 9 flights from 1989 to 2003, New Mexico, Canada
 - 3 flights 2003 to present, New Mexico, Kiruna
 - Ozone “hole” and heterogeneous photochemistry as a cause suggested from Antarctic balloon flight (D. Hoffman, S. Solomon)
 - Balloons played a *huge* role in ozone science
 - **Ozone Photochemistry since 1995**
 - SOLVE, AURA validation campaigns (New Mexico, Kiruna)
 - **Understanding of ozone photochemistry and international regulations of CFCs has led to de-emphasis of ozone science and hence ballooning**
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Historical Development of Satellite Instruments for Earth Sciences - 1970's



- Airborne Application Flight Experiments (AAFE) Program
 - Aircraft and Balloon Testbed for future satellite instruments
 - Led directly into space flight in many instances
- 1970's Satellite Programs especially NIMBUS
 - Developed and demonstrated many techniques in space commonly used today
 - Ocean surface properties (SEASAT)
 - Infrared Limb Sounding (LRIR; LIMS; SAMS)
 - CLAES, ISAMS, SABER, SAGEs
 - Earth Radiation Budget Sensing (ERBS)
 - ERBE, CERES
 - Atmospheric Spectral Sounding (IRIS)
 - AIRS, CrIS, etc.

1990's - Present

- **Instrument Incubator Program (IIP)**

- Since 1998
- Purpose is to develop/demonstrate technologies
- Retire risk for future satellite sensors
- Requires demonstration of technologies in “relevant environment”
- Almost all IIP with flights choose aircraft
- Counter example: Langley FIRST instrument

- **New Millennium Program (NMP)**

- Technology demonstration for future science missions
 - EO-1 (Land imaging)
 - EO-3 (GIFTS; weather forecast improvement; not flown)
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Balloon or Aircraft: An Earth Scientist's Dilemma



- **Aircraft**

- Almost “anywhere, anytime” - except perhaps Antarctica
- Acoustic, thermal, mechanical environment often less than desirable -- especially for testing new instruments
- Limited measurement time and requires human pilot
- UAV's touted as future of airborne remote sensing

- **Balloons**

- Limited geographic and temporal opportunities
- Very quiet, stable environment relative to aircraft
- Longer measurement time, especially if ULDB/Airships available

- Recent NASA science focus more on tropospheric field campaigns than on stratospheric validation
 - Aircraft often chosen over balloons as NASA science field campaigns are often not accessible by balloons -- e.g., current TC4 in Costa Rica
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Earth Science Missions In Development



- Much of current Earth Science portfolio focused on lower atmosphere and “climate” (NASA Science Plan 2007)
 - Landsat Continuity Mission
 - Ocean Surface Topography
 - Orbiting Carbon Observatory
 - Aquarius (Sea salinity)
 - Global Precipitation Mission
 - Glory (Cloud properties - delayed/cancelled??)
 - NPOESS Preparatory Project (NPP)
 - Primarily tropospheric weather/climate
 - Total ozone and ozone profiling (OMPS, if restored)
- Opportunities for balloon validation most likely for OMPS
- Airships may be viable for correlative measurements if developed in time

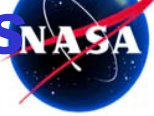


Potential Future Contributions to Earth Sciences

- ROSES-2007 IIP calls directly for technology/instruments relevant to NRC Earth Science Decadal Survey
- NRC Decadal Survey:
 - Recommends 15 Earth Science missions 2010-2020
 - Will require extensive instrument development and demonstration
 - All instruments are new under the “JPL rule of thumb”
 - More than 10-15% different from existing instrument = NEW
- Balloon Program today provides optimal platform for prototype demonstration for Decadal Survey
 - LEO, GEO: balloons especially nice for GEO demo
 - FTS; radar; lidar; spectrometers;
 - Example: Langley FIRST Instrument

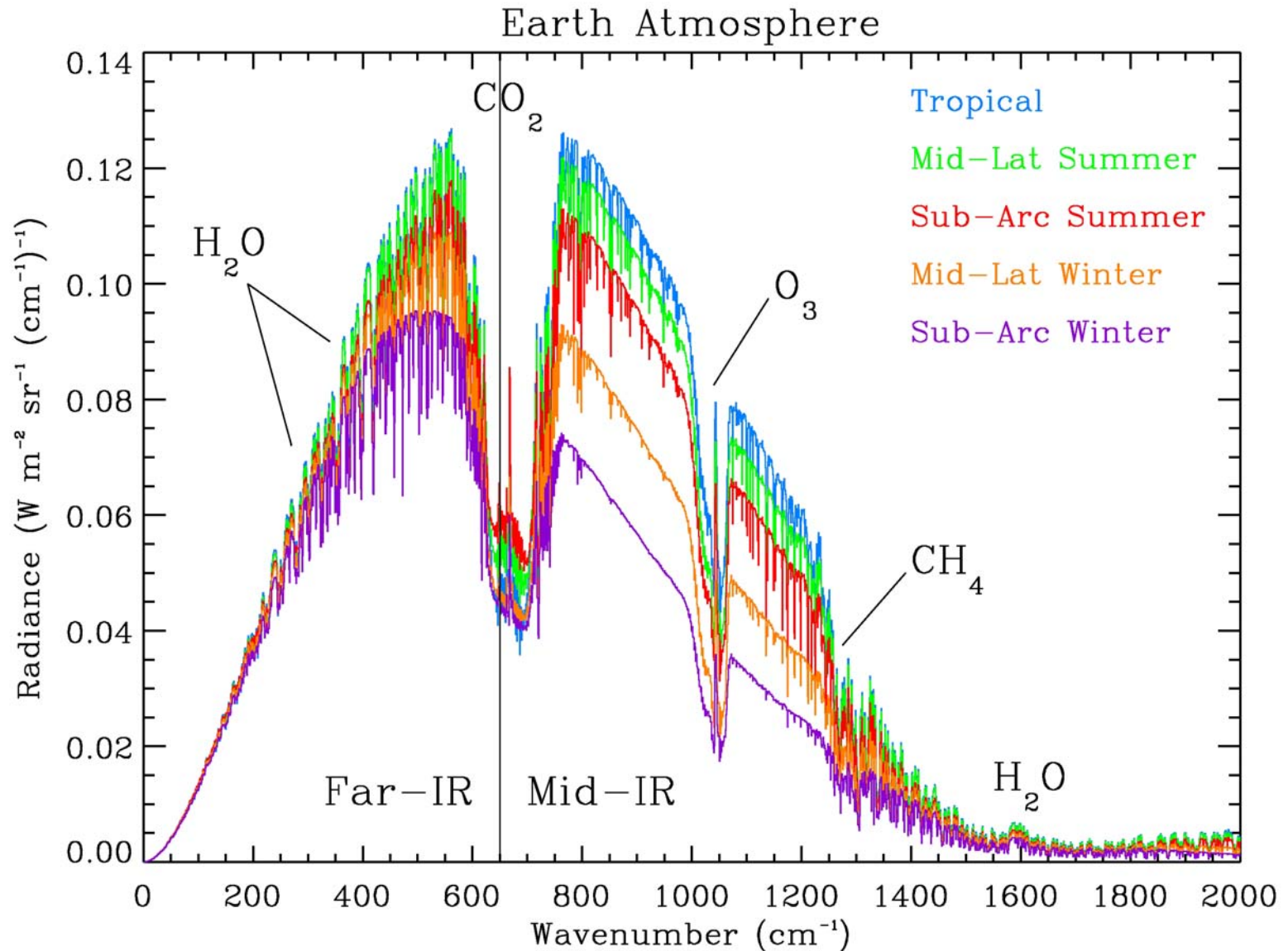
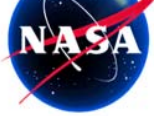
Example for Decadal Survey Instruments

Flight Demonstration of FIRST

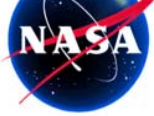


- Far-Infrared Spectroscopy of the Troposphere
 - Developed 2002 - 2005 under IIP
 - Measure 1/2 of the IR emission spectrum not presently measured from space
 - Needed to develop FTS, beamsplitter technology
 - Chose balloon as optimal demo platform
 - Readily simulates space environment
 - Quiet platform preferred by FTS
 - High altitude offers “space view” for calibration
 - Easy overpass for validation and new science with the “A-Train” and other satellites
 - AQUA, TERRA, CALIPSO, AURA, TIMED
 - Substantial assets in space not available in past - enhances balloon science potential enormously
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Earth's Outgoing Longwave Radiation

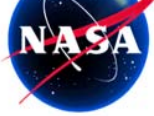


Instrument Overview: FIRST on Balloon Gondola

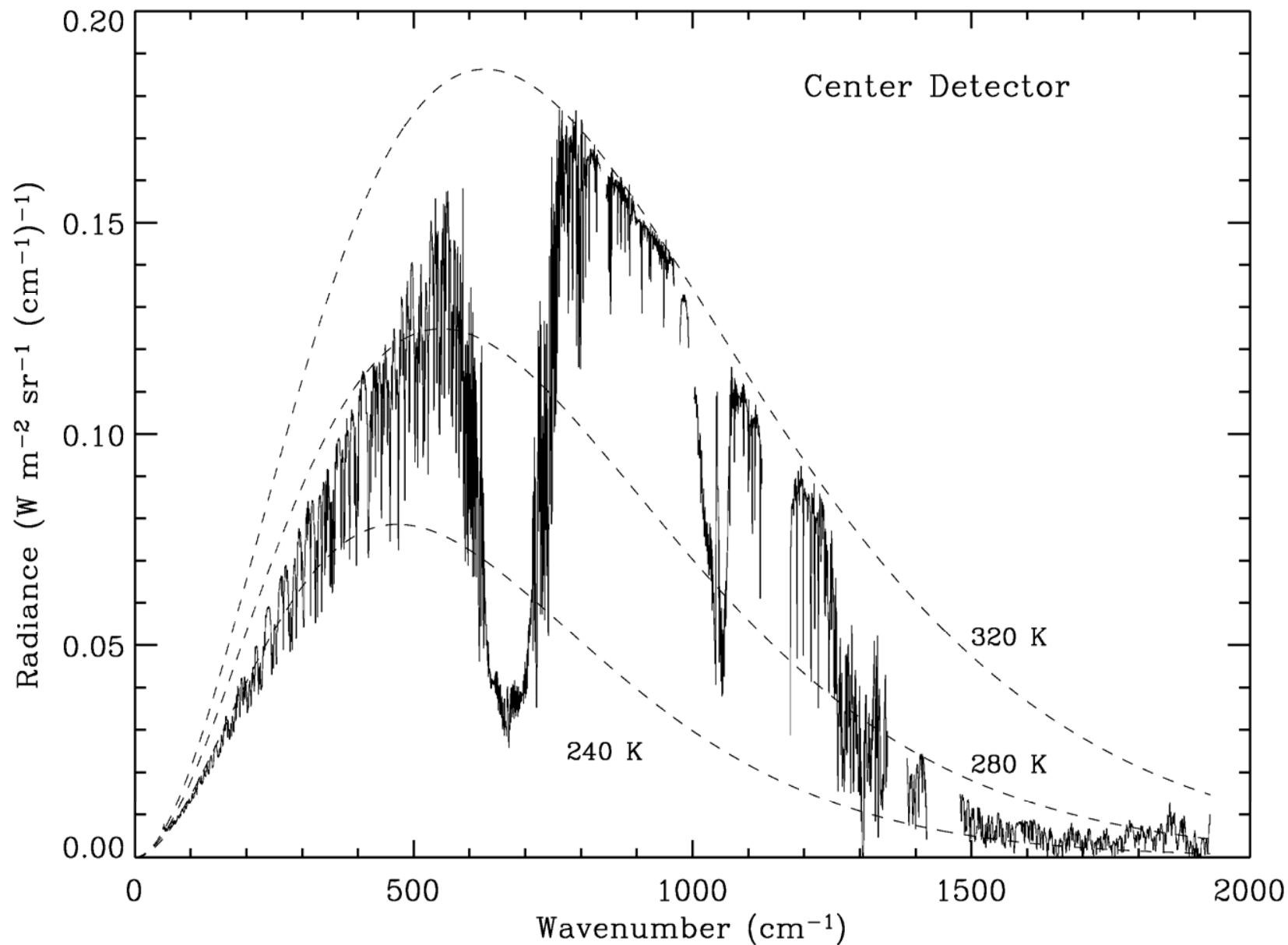


Front view

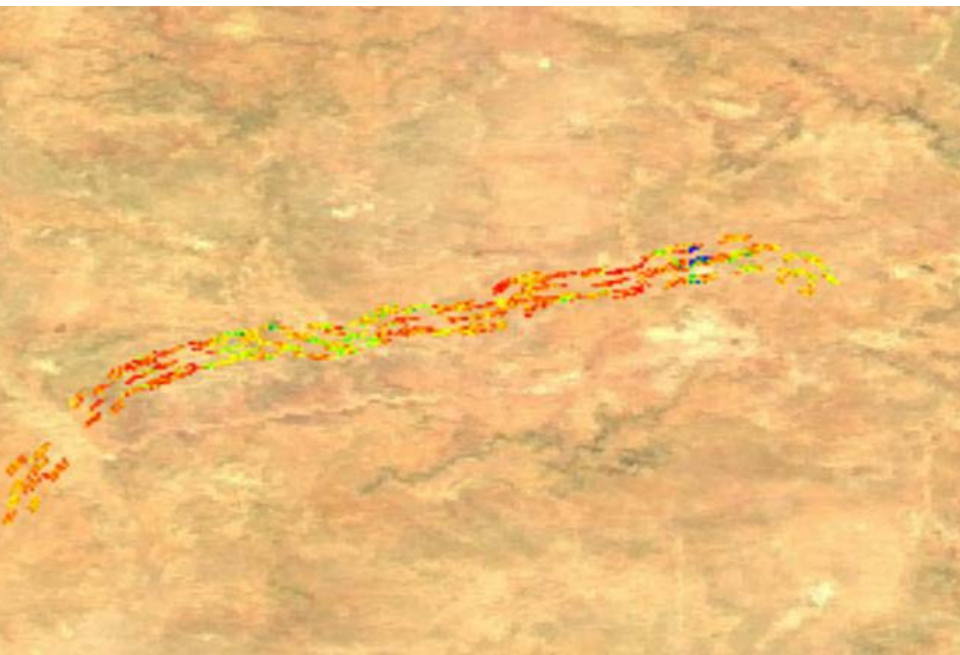
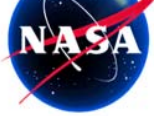
FIRST Ready for Launch



FIRST Radiance June 7 2005 14:25 LT

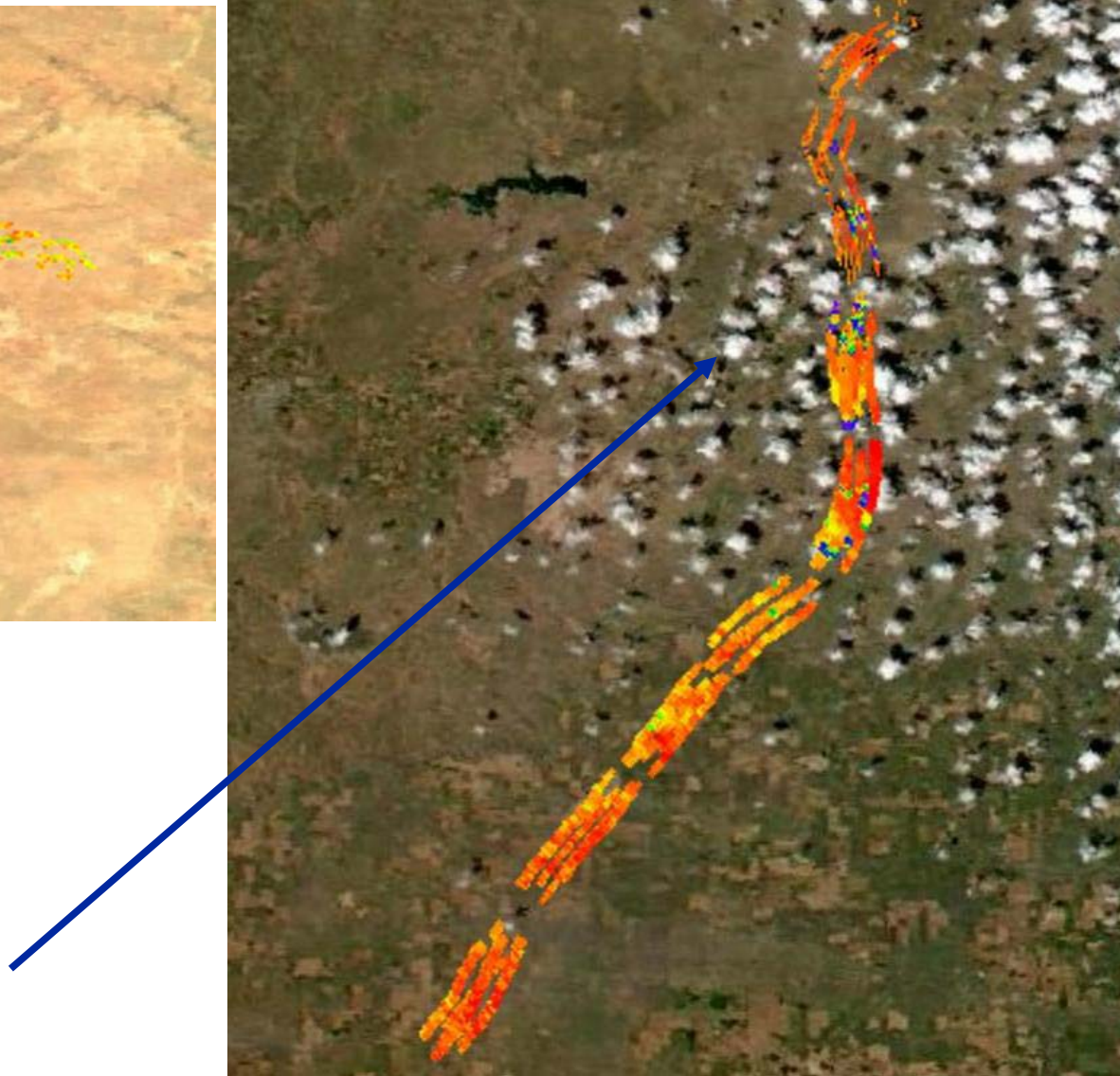


FIRST 820 cm⁻¹ Brightness Temperature 250 m MODIS Visible Imagery

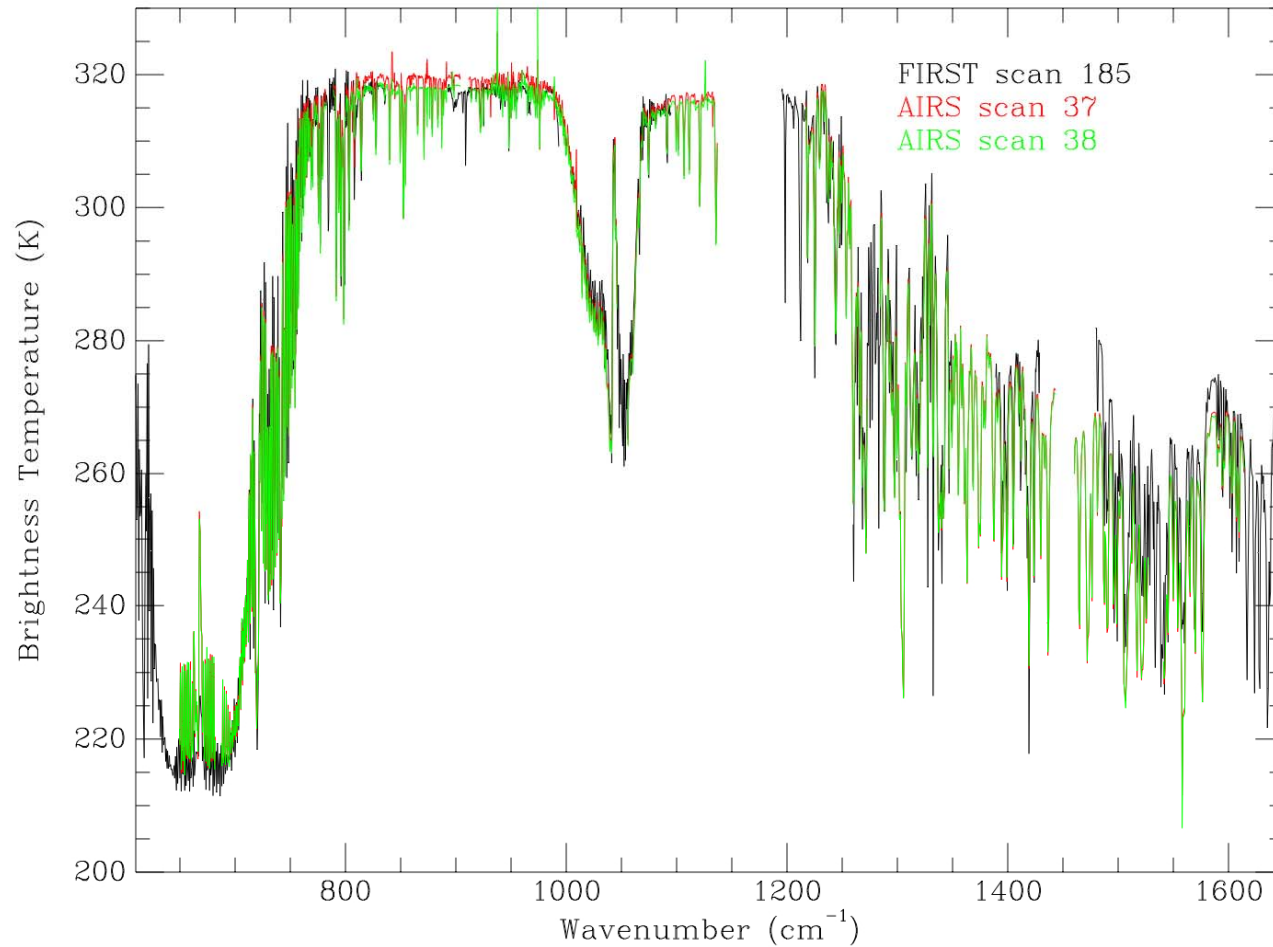
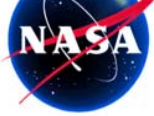


June 7, 2005

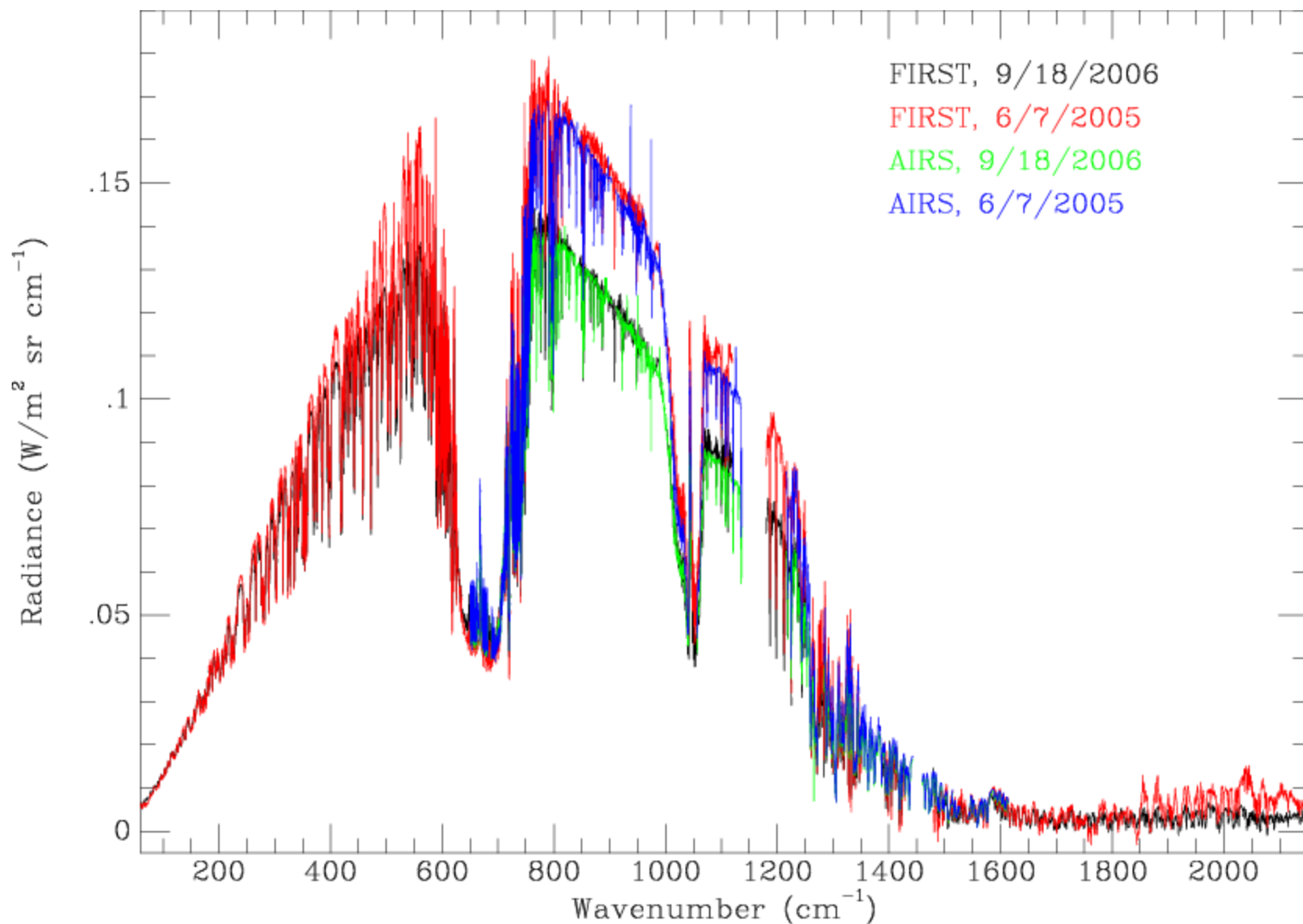
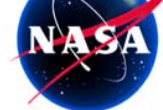
**September 18, 2006;
Note clouds in image**



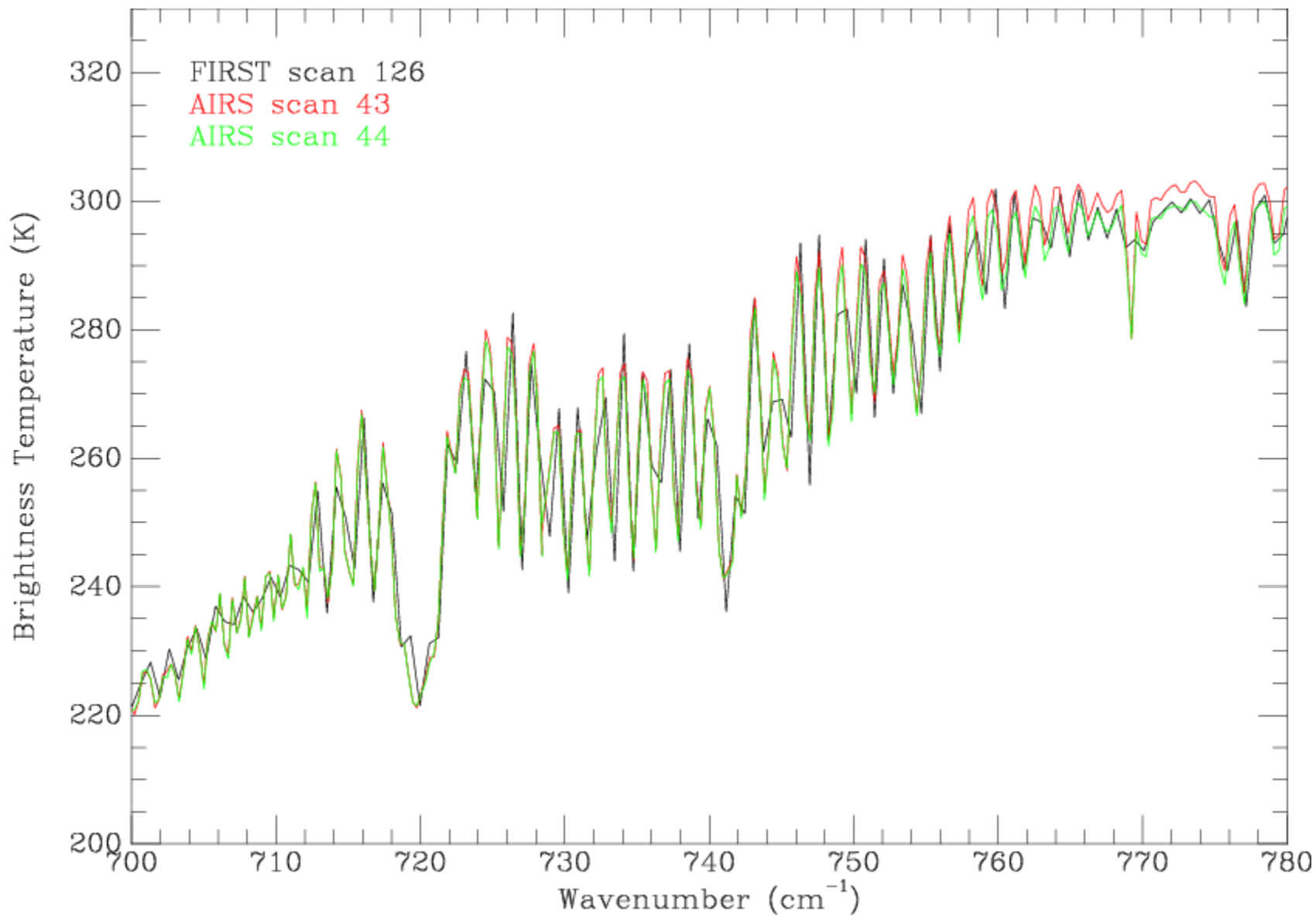
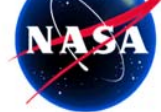
FIRST and AIRS T_B Comparison June 2005



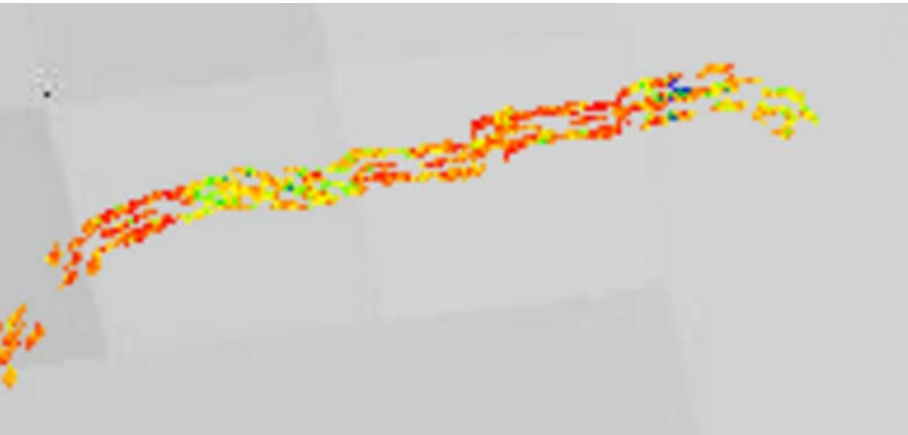
FIRST-AIRS Radiance comparison



Detailed AIRS Comparison



FIRST 820 cm⁻¹ Brightness Temperature AIRS 820 cm⁻¹ Imagery



June 7, 2005

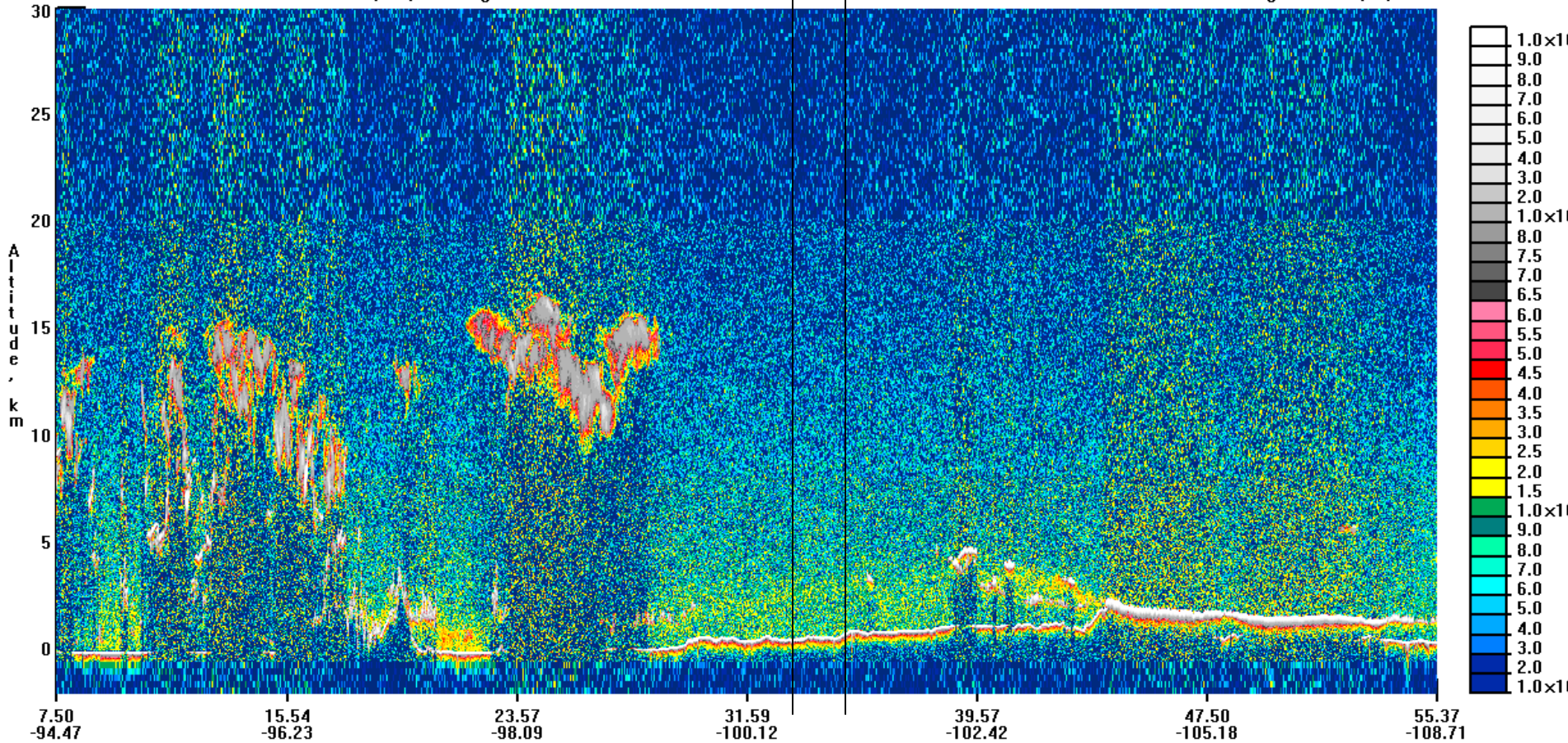
September 18, 2006



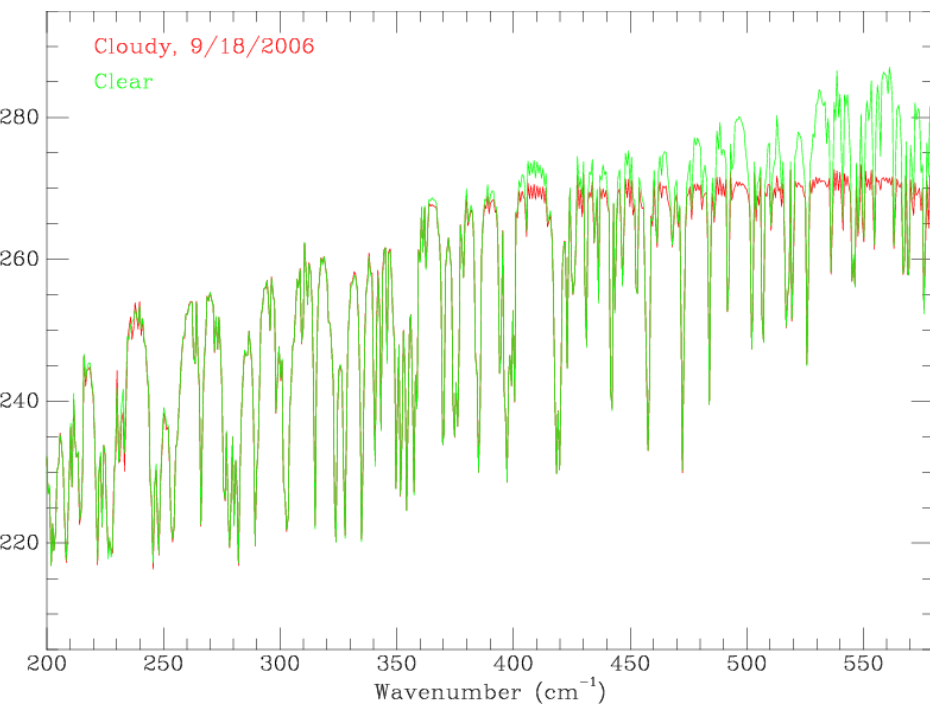
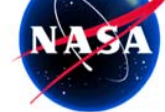
CALIPSO Data 9/18/2006



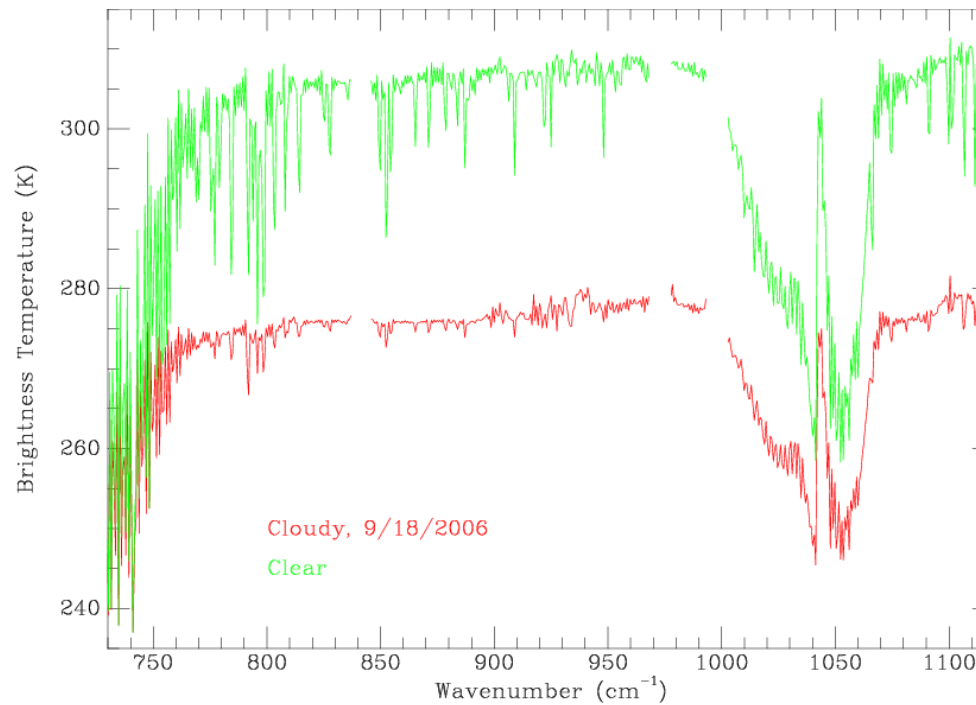
532 nm Total Attenuated Backscatter, /km /sr Begin UTC: 2006-09-18 19:57:25.2312 End UTC: 2006-09-18 20:10:44.2072 Version: 1.07 Image Date: 09/20/2006



Comparison of Cloudy and Clear Spectra

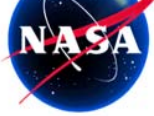


Far-Infrared



Mid-Infrared

FIRST Summary



- FIRST project demonstrates continued contribution of balloon program to meet NASA needs:
 - Demonstration of new technology for future space flight instruments
 - Correlative science with existing space-based standards (AIRS)
 - New science offered by first-ever observations (CALISPO and A-Train + FIRST)
 - Allows challenges related to calibration to be worked out prior to launch
 - The large number of Earth Science assets already in orbit make ballooning very attractive for test and validation of new sensors

Substantial potential for developing and validating new sensors for the Decadal Survey Missions utilizing high altitude balloons

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- ULDB's may open new opportunities for Earth Science - especially if maneuverable
 - Airships - especially attractive for high-value assets
 - “Sensor Webs” for studying the Earth
 - Earth Science community now tending towards UAV
 - Balloons not considered perhaps because of lack of knowledge of ULDBs or Airships
 - Recommend BPO host a community workshop on scientific balloon capabilities for Earth sciences
 - Perhaps start with a Town Hall Meeting at AGU
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Almost there...

